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ABSTRACT

A curriculum on the language arts was designed especially for hearing-impaired students for use with computer-assisted instruction (CAI). Basically the third-grade level is approximated in the curriculum which is designed as a supplementary but self-contained set of lessons. There are 214 lessons of 20-30 exercises each, approximately sufficient for an entire school year. The major features of the curriculum are the interactive student control and the branching to different sets of lessons, determined by individual student needs. A feature of the computer program is the daily and periodic student reports which are available. A language arts test was developed and used in an evaluation experiment in which five different models of student progress were tested. In addition, experiments on the teaching strategies and sequences of tutorial CAI were performed. The latter experiments involved an item analysis of the lesson exercises. (WH)

COMPUTER-ASSISTED INSTRUCTION IN LANGUAGE ARTS FOR HEARING-IMPAIRED STUDENTS

BY

J. D. FLETCHER AND M. H. BEARD

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COMPUTER-ASSISTED INSTRUCTION IN LANGUAGE ARTS FOR HEARING-IMPAIRED STUDENTS

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J. D. Fletcher and M. H. Beard

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October 31, 1973

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STANFORD UNIVERSITY

STANFORD, CALIFORNIA

COMPUTER-ASSISTED INSTRUCTION IN LANGUAGE ARTS FOR HEARING-IMPAIRED STUDENTS[1]

J. D. Fletcher and M. H. Beard[2]

In June 1970, the Institute for Mathematical Studies in the Social Sciences (IMSSS) began a three-year project on the development, evaluation, and research of computer-assisted instruction (CAI) for hearing-impaired, or 'deaf', students. In the course of this project over 4,000 students from 15 schools for the deaf in five different states received CAI in algebra, basic English, computer programming, elementary-school mathematics, language arts, logic, and arithmetic word problem solving furnished by the IMSSS computer facility at Stanford. Most of these curriculums were described in detail by Suppes, Goldberg, Kanz, Searle, and Stauffer (1971). Overviews of IMSSS activities in CAI were provided by Suppes (1972), Suppes, Jerman, and Brian (1968), and Suppes and Morningstar (1972). Fletcher and Stauffer (1973), Kanz (1973), and Suppes (1971) specifically discussed the IMSSS project for the deaf, and the accomplishments of the project were summarized by Fletcher and Suppes (1973). The aims of the project were to demonstrate that CAI could be used to benefit deaf students, that it could support serious research in deaf education, that its economics were practicable, and, in general, that CAI was workable in deaf education.

THE STANFORD CAI SYSTEM

The central processor for the Institute's computer system is a Digital Equipment Corporation PDP-10. In addition to 256K of core memory, short-term storage of programs and student information is

provided by sixteen 180,000,000-bit disk modules. Long-term storage of student response data is provided by magnetic tape. About 280,000,000 bits of information can be stored by the system on one magnetic tape. Communication with remote student terminals in participating schools is provided by private telephone lines. For communication with clusters of 16 or more terminals, high-speed data transmission and time-division multiplexing are used. About 90 CAI terminals can be used simultaneously with no appreciable detriment in the system's speed of response. Any curriculum or other program can be run at any time on any student terminal.

The student terminals are "KSR Model 33" teletypewriters. These teletypewriters provide no audio, visual, or graphic capability, but their cost is about one-tenth of terminals that do. Despite their limitations, these inexpensive terminals permitted development of CAI that has produced dramatic gains in pedagogical achievement for hearing students as reported by Suppes and Morningstar (1970, 1972), Fletcher and Atkinson (1972), and others. For that matter, Jamison, Fletcher, Suppes, and Atkinson (1974) argued that for cost effectiveness, CAI, using satellite communication and teletypewriters, is a superior method for providing compensatory education.

In a typical school one room contains 8 to 15 student terminals. One person, the CAI terminal proctor, supervises use of the equipment and students in the terminal room. Usually accompanied by their classroom teacher, the students enter and sit at any free terminal. Each student starts instruction by pressing a key to signal that he is positioned at the terminal and is ready for attention. The program responds by typing

HI

PLEASE TYPE YOUR NUMBER AND NAME.

and the student responds accordingly.

Each student receives a unique number when he enrolls for CAI, so the request for the first name is merely an additional safeguard to ensure correct identification. A student can be, and usually is, enrolled for several available CAI courses. He uses the same number for all courses and types a one-letter identifier to indicate which course he wants. The student in the following example types G, the identifier for the language arts course. Unless he types special instructions, the student begins exactly where he left off in the sequence of lessons. Student responses in the following example are underlined.

HI

PLEASE TYPE YOUR NUMBER AND NAME.

G3456 MARY SMITH

JOB 10 ON TT5013 FRI FEB 2 73 8:46AM-PDT

PRONOUN LESSON PNAC

//CHOOSE THE CORRECT PRONOUN.

I LIKE THAT GIRL.

I LIKE (SHE, HER).

DESCRIPTION OF THE LANGUAGE ARTS CURRICULUM

Deaf students consistently score lower than hearing controls on measures of English language ability as Goetzinger and Rousey (1959), Miller (1958), and Moores (1970), among others, have reported. It is natural, therefore, that language skill subjects such as speech,

vocabulary, composition, grammar, reading, and speech-reading are emphasized in deaf education, and the language arts curriculum was emphasized in the Stanford CAI project.

The effort in the language arts program was to develop a CAI curriculum in standard English usage and a related paper-and-pencil test for students between the ages of 12 and 16 enrolled in special schools or classes for the deaf. The reading level of both the curriculum and the test was tailored for this population. Rawlings' (1971) survey reported that 74% of the students in these schools and classes have suffered a hearing loss of 60 decibels or more in the better ear. Mean grade placement (GP) reading levels measured by the Stanford Achievement Test (SAT) for hearing-impaired students 12 to 16 years of age are given in Table 1.[3]

A vocabulary list was generated for the curriculum by compiling the words common to the third-grade vocabulary lists of four widely used basal readers: Scott-Foresman (Robinson, Monroe, & Artley, 1962), Lippincott (McCracken & Walcutt, 1964), Ginn (Russell & Ousley, 1968), and Macmillan (Gates, Huber, & Salisbury, 1966). Although words not found in this list were occasionally used, an attempt was made to restrict the curriculum vocabulary to this list. The list is given in Appendix A. A Dictionary of Idioms for the Deaf (Boatner & Gates, 1966) was also consulted in determining the vocabulary for the course. Teachers in the participating schools emphasized that idioms are confusing to their students, and an attempt was made to avoid idiomatic constructions.

Most language curriculums in schools for the deaf are based on the Fitzgerald Key (Fitzgerald, 1949). This system classifies all words

Table 1

Total Reading Grade Equivalencies for Students with a Hearing-Loss Threshold of 60 Decibels and Above (Gentile and DiFrancesca, 1969)

Stanford Achievement Test Battery	Age 12	13	14	15	16
Primary II	2.41	2.51	2.44		
Intermediate I	3.41	3.46	3.33	3.33	3.35
Intermediate II		3.97	4.31	4.24	4.17

and phrases into categories identified by such words as "who," "what," "where," and "when." Deaf students are taught standard English usage by identifying the Fitzgerald category to which words in question belong. The teacher is to focus on words suggested by objects in the room or experiences of the students. Because this method depends heavily on classroom experiences and because consultants called in to aid in the design of the curriculum recommended a fresh approach, the Fitzgerald Key was used only sparingly.

The basic problem in teaching English to deaf students is that they have little or no aural language on which to build. Unlike a hearing student, the deaf student is unlikely to have internalized much English syntax, inflection, or vocabulary before he starts school. Rawlings' (1971) survey reported that 75% of students in special classes for the deaf experienced hearing loss before age three. There is a real possibility that the deaf child never assimilates the basic principles of English that a hearing child acquires at an early age (Charrow & Fletcher, 1974; Lenneberg, 1967). For a deaf child, learning to read is more than a grapheme-to-phoneme decoding task; it is actually learning a language from its written form. Learning to write standard English is similarly complicated for deaf students.

The language difficulties of deaf students were carefully considered in developing the language arts curriculum. The curriculum was designed to stress the structure of English, with particular emphasis on the roles of syntax and inflection and on the meaning of function words. An inductive rather than a deductive teaching strategy was emphasized. Therefore, the course does not explicitly state 'rules' of English usage, but

presents items illustrating aspects of standard usage. Incidental learning of basic sentence patterns is enhanced by presenting curriculum items in complete sentences. Fewer than one-tenth of the exercises present the student with single words or isolated phrases. Incidental learning is also enhanced by requiring many constructed rather than multiple-choice responses.

The course is not intended to be a complete course in English. Classroom instruction remains the largest portion of the student's language experience, whereas the CAI course provides supplementary, individualized drill. On the other hand, the course is self-contained, and it supplies as many appropriate explanations and examples as possible. The classroom schedule of instruction need not be altered to adapt to the sequence of instruction in the CAI course, although paper-and-pencil drill given in the classroom can be reduced. No specific instruction in standard English usage is needed by students beginning the course.

Lessons and Content

The curriculum is divided into 214 lessons of 20-30 exercises each. These lessons include review tests that occur about once every 12 lessons. It was designed to provide a student in the target population with enough 10-minute daily sessions for an entire school year. An outline of the 1972-73 version of the course is included as Appendix B. Separate topics are presented in separate lessons and there are several sequences of lessons on a single topic. The lessons are ordered to provide a cumulative basis of concepts building upon one another. Several lessons review topics presented in preceding lessons.

Although the content of the language arts course does not differ markedly from other language study courses for deaf students, its method is necessarily different. Its design includes: (a) consistency of format, (b) unambiguity of "correct" answers, (c) specific correction messages appropriate to incorrect responses, (d) internal data collection, (e) branching around blocks of material for more able students, and (f) interactive student control.

Formats of instructions are consistent and unambiguous. The student is always allowed the options of having the problem repeated, frequently with a "help" message further clarifying the task, or of requesting the correct answer to any problem. Instructions are as short as possible, and the nature of the task is the same throughout a lesson.

Students taking the course may receive appropriate correction for particular wrong responses. For almost every exercise throughout the course, careful attention has been given to a variety of likely wrong answers. Short, but helpful messages, explaining the nature of the error, are returned immediately after particular wrong responses. An attempt is made at all times to reinforce any response that contains a part of the correct answer and to lead the student to the complete correct answer.

CAI differs from ordinary classroom instruction particularly in the ability to store complete response data. This ability qualifies it as a research tool as well as a teaching medium. Precise information on each student's response is stored for later analysis and revision of the course. Daily reports are written and may be listed by teachers and the IMSSS staff to monitor each student's progress and lesson scores.

If a lesson introduces a new topic, carefully sequenced explanation and instruction are given in a short "tutorial" section at the beginning of the lesson. In subsequent lessons on the same subject, short but complete instructions are given. This tutorial instruction allows students to proceed through the course without waiting for group instruction on each new topic.

In all lessons except the review tests and the first introductory lesson, a student who demonstrates an ability to perform the task required early in the lesson is automatically branched to the next lesson. This is accomplished by a checkpoint after 6-9 items, requiring 85% correct responses on the first attempt to execute the branch. In the "directions" lessons at the beginning of the course, scores are checked more frequently, allowing a student who has mastered the task by the middle of the lesson to bypass the rest. This branching allows a student who is proficient on one topic to branch ahead to a topic with which he may be less familiar.

The order in which the lessons are given in Appendix B is the order in which most students take them. The lessons are interrelated in that concepts introduced in earlier lessons are used to explain concepts introduced in later lessons. However, lessons can be taken out of sequence. Each lesson is self-contained in that the task is completely explained and, except for the mixed drill lessons, each lesson focuses on a specifically defined task. A teacher can easily alter the order in which students encounter lessons to conform more closely with the development of classroom work, or to provide students with review lessons on a specific topic.

Suggestions for the curriculum content came from many sources. One of the most important of these was the Kendall School for the Deaf in Washington, D.C. Stanford and Kendall staff members worked together during the spring and summer of 1970 to develop programmed lessons in English usage for students at the school. This was part of a larger Kendall plan to develop curriculum material in transformational grammar for deaf students. The content of the language arts course reflects this early cooperation, and the curriculum is oriented toward transformational grammar, although more traditional approaches to teaching standard usage are also included. Many ideas were drawn from The Roberts English Series (Roberts, Ross, & Boyd, 1970), and the workbooks for the series furnished examples for specific items.

Another valuable source of content suggestions was a group of research specialists in curriculum development for the deaf. The entire group met with the Stanford staff in the fall of 1970, and individual consultants have continued to make suggestions since that time.

Teachers from the schools whose students used the course were encouraged to contribute ideas and criticism. In some cases, teachers' suggestions have resulted directly in a series of lessons. Comments on early lessons in the curriculum were incorporated in planning and writing later lessons and in revising the curriculum.

Finally, samples of written work by students at Kendall School and California School for the Deaf at Berkeley were studied to indicate problem areas peculiar to deaf students. Results from a detailed study of the grammar and vocabulary of this early corpus were reported by

Fletcher, Jamison, Searle, and Smith (1973). This study confirmed some tentative conclusions that had guided the course structure and content.

Terminology used in the language arts course reflects the blend of transformational and traditional approaches mentioned above. To some extent, it uses the terminology found in the Roberts' series through the fourth grade. This terminology is not substantially different from that used in other curriculums reviewed by the Stanford staff. Greater precision is afforded by use of some Roberts' terms; e.g., the common term "auxiliary" is not used because understanding the function of elements commonly called auxiliaries in the phrases presented by the curriculum requires a set of more precise terms, so the Roberts' term "modal" is used to identify constituents such as can, may, will. In addition to terms taken from other language curriculums, some labels were invented specifically for the language arts course to keep the terminology as short and clear as possible. Thus, for example, "ing-form" is used instead of "present participle," "have-word" for "form of the verb have," "not-sentence" for "negative sentence."

Interactive Student Control

The language arts course is structured in a linear sequence of lessons. The program-selected ("automatic" order) lessons are shown in the course outline (Appendix B). Similarly, there exists for each problem a usual or "automatic" sequence of events: the exercise is printed, the student responds, the program prints an error message if he is incorrect, he eventually types the correct answer, and the program prints the next exercise. If the student exceeds his maximum number of

trials for an exercise, the program automatically prints the correct answer in a standard format before proceeding.

Many students follow this standard sequence. However, the program also allows the student or his teacher or proctor to modify his interaction with the curriculum in the following ways:

1. CTRL-Z allows the student to terminate his session at any time. The program does not impose a time limit, so the length of student sessions may be determined by the school, the proctor, the teacher, or by the student himself.

2. CTRL-A causes the program to reprint the instructions and the current exercise. Depending on the complexity of the exercise, a helpful message may also be printed.

3. CTRL-G allows the student or teacher to specify a particular point in the curriculum for that student. This option may be used if the teacher wishes to use a sequence of lessons other than that listed in the outline and automatically presented by the program. It is useful for students who need instruction and practice in a specific subject area.

4. CTRL-T causes the program to print the answer to the current exercise without waiting for the maximum number of trials. This option provides an immediate escape from an exercise that is too difficult for a given student.

5. CTRL-H causes the program to skip the current exercise and to print the next exercise. It is useful to teachers who wish to review the lesson material quickly.

Thus the course can be quite flexible. If a school or teacher wishes to use the entire course as outlined, students can run the program virtually by themselves without the help of a teacher or proctor, especially by using the CTRL-A and CTRL-T options. If more specific instruction is desired, a minimum of effort is necessary to tailor the program's presentation to any student's needs.

Objectives

The course begins with 10 introductory lessons. The first lesson familiarizes the student with the teletypewriter, emphasizing such potential sources of confusion as the number "one" and the letter "I," and the number "zero" and the letter "O." The nine "directions" lessons that follow serve two purposes: (a) they provide material requested in early consultations by some teachers of deaf students, and (b) they familiarize the student further with the different kinds of instructions he will encounter later. These lessons are parallel to, but not as extensive as, The Language of Directions by Rush (1970).

The specific objectives of the directions lessons are that students should be able to:

1. Type any letter or letters in a given word identified by one of the following: ordinals ("first" through "fourth"), "after the first," "first two," "last," "before the last," "last two."

2. Type any word or words in a given sentence identified by one of the following: ordinals ("first" through "fourth"), "after" or "before" a given word, "before the last."

3. Copy a two- or three-word phrase from a given sentence, including spaces between words.

4. Given two or three rows of numbers (each row containing up to five numbers), type any number whose position is specified by "above," "below," or "under" another number.

There are four general course objectives. Students are expected to:

1. Recognize specified grammatical categories.

2. Recognize and supply various forms of given grammatical structures.

3. Select appropriate grammatical units to complete a specified structure.

4. Perform specified transformations on grammatical structures.

Under (1) of the general course objectives the following parts of speech and grammatical structures are explicitly identified: noun, determiner, noun phrase, verb, adjective, subject, predicate, pronoun, modal, vowel, preposition, prepositional phrase, and contraction. The student should be able to recognize the structure and identify the structure in a sentence. The specific tasks are:

a. Identify one or more nouns, in either a nominative or an objective position.

b. Identify one or more of the following as determiners: "a," "an," "the," "some," "every," "no," "all," cardinal numbers from "one" to "ten," and double determiners with "all" or cardinals.

c. Identify isolated vowels, and select from a group of words the one that starts with a vowel.

d. Identify nominative and objective noun phrases of the following types: single noun or pronoun, determiner-noun, determiner-adjective-noun, determiner-determiner-noun, adjective-noun, determiner-adjective-adjective-noun.

e. Select from a given sentence one or more nouns specified as singular or plural.

f. Identify verbs in the simple present, present progressive, simple past, past progressive, modal form, or "be-word" form.

g. Identify specifically verbs in the simple past tense.

h. Identify as modals: "can," "could," "will," "would," "should," "may," "might," "must"; identify as "be-words": "am," "is," "are," "was," "were"; identify as "have-words": "have," "has," "had."

i. Identify the complete simple or compound subject and the complete predicate of a given sentence.

j. Identify as pronouns: "he," "she," "it," "they," "I," "you," "we," "me," "him," "her," "us," and "them"; and as possessive pronouns: "my," "his," "her," its," "your," "our," and "their."

k. Given a declarative sentence and a related question, identify the nominative or objective noun phrase that answers the question.

l. Identify as prepositions: "in," "to," "of," "for," "with," "on," "at," "by," "from," "after," "into," "over," and "before."

m. Identify prepositional phrases of place and time of the forms: preposition-noun, preposition-determiner-noun, preposition-adjective-noun, preposition-determiner-adjective-noun.

n. Given a declarative sentence and a related question, identify the prepositional phrase that answers the question.

o. Identify contractions of "be," "have," and "do."

Under (2) of the general course objectives, the student should be able to:

a. Supply the plurals of given singular nouns, and the singulars

of given plural nouns. Both regular and irregular plurals are used.

b. Indicate whether a specified noun phrase is singular or plural.

c. Given the root form of a verb, supply the gender marked form, simple past, or present participle. Verbs given are regular (including those ending with single consonants and -y) and the irregular verbs "have," "go," and "do" in the third person singular and past forms.

d. Indicate whether the subject of a sentence is singular or plural.

e. Given the gender marked form or the simple past form, supply the root form of the verb.

Under (3) of the general course objectives, the student should be able to:

a. Type "a" or "an" before a given noun in a sentence, depending on the first letter of the noun.

b. Choose from two given determiners the one that agrees in number with a given singular or plural noun in a sentence.

c. Choose from two to seven given pronouns the one that is appropriate either in number or gender or case or all three for the noun phrase that it will replace.

d. Choose the correct inflection of a verb based on subject-verb agreement in number.

e. Choose the correct inflection of the present tense of "be" to complete a sentence.

f. Given the root form of a verb, construct the correct form of the present progressive to complete a sentence.

g. Choose the correct noun or pronoun to complete the subject of a sentence based on subject-verb agreement in number.

h. Choose the correct preposition to complete a sentence.

Under (4) of the general course objectives, the student should be able to:

a. Combine two related sentences into one by specifying the position of an adjective to be inserted.

b. Indicate the negative transform of a given sentence (including a modal, a form of "have," or a form of "be") by specifying the position of "not."

c. Construct a possessive noun phrase from a sentence of the form: noun phrase, form of "have," noun phrase.

d. Make a contraction of "be" and a pronoun or noun phrase.

e. Expand a contraction of "be" from a given sentence.

f. Make a negative contraction of "be," "have," or "do."

g. Expand a negative contraction of "be," "have," or "do."

h. Indicate the question transform of a sentence by specifying the modal, have-word, or be-word that changes position.

Reports

A daily report program makes available detailed information on student progress. The report gives information by IMSSS class number and is available both to teachers in the participating schools and to IMSSS staff. An example of a daily report is shown in Figure 1. The report heading documents the class number, teacher's name, date of the report, number of students in the class (including those not flagged for the language arts course), name of the school, and class grade. The first number in the row of student information is the total number of lessons the student has completed to date. The number following that

CLASS 542 MR. RAPHAEL 10 APR 72
9 STUDENTS -- VICTORIA SCHOOL - HOUSTON -- GRADE 5

LANGUAGE ARTS (G) REPORT

57(5) LESSONS 40/41 = 97% 19.1 MIN + 2834 JERRY HOPKINS
DAD 23/26 MAE 7/ 7 NPAC 7/ 8 DAI 7/ 7
DAF 3/ 7 DAG (CONT)

23 TOTAL LESSONS 2837 MATT ARNOLD

2 TOTAL LESSONS 2950 BILL MORRIS

Figure 1. Illustration of language arts curriculum daily report.

in parentheses is the number of lessons completed on that day. After the word LESSONS, the program prints the total score for the day (number of correct responses/number of completed problems) and converts the score to percentage correct. The number of problems includes all problems completed on that day, not just the problems in the completed lessons. Following the percentage score is the total number of minutes the student has accumulated in the curriculum, a plus sign if the student used the course on the date of the report, the student's number and his name. On the second and following lines, the report lists the names of lessons the student completed on the day of the report, giving a score for each lesson (number of correct responses/number of completed problems). If the student stopped in the middle of a lesson, that lesson is listed but the score is not reported. Exercises completed in unfinished lessons will be added to the daily totals reported on the first line. If the student has not taken a lesson on the date of the report, only his number, name, and total lessons completed will appear.

Another report is available that gives for each student all the lessons completed to date by name and includes number of problems taken, percentage correct for each lesson, and an ordinal to indicate the order in which the lesson was taken. This report is not available 'on line' as is the daily report, but it is prepared and sent to teachers upon request. An example of this report is given in Figure 2. The report is generated by scanning the stored student response data for a given class of students over a given period of time. The class number and period scanned are given in the heading.

CLASS 401		10-26-1971 THRU 12-17-1971				STUDENT 460			JOYCE CAREY		
DAH			VAA	7	100%	VAB	7	100%	MAF	7	85%
VAC	7	100%	VAD	7	85%	MAG	8	100%	TC	19	78%
VAE	28	57%	AJAA	7	85%	AJAB	7	100%	AJAC	23	69%
MAH	28	85%	MAI	27	77%	NPAD	22	77%	NPAE	25	72%
NPAF	21	57%	AJAD	20	65%	MAJ	21	76%	MAK		

CLASS 401		10-26-1971 THRU 12-17-1971				STUDENT 461			GULLY JIMPSON		
INTRO	28	85%	DIR	21	61%	DIR2	7	100%	DIR3		

Figure 2. Example of the off-line language arts report for two students in class 401. The period scanned was October 26, 1971 to December 17, 1971. The entry for each lesson consists of lesson name, number of exercises completed in the lesson, and percentage correct.

Curriculum Revision

Based on the analyses of items and lessons, the curriculum was revised during the summer of 1972. Thirty-seven lessons were deleted from the 1971-72 version of the curriculum, 42 new lessons were added, and 13 review tests were included, making a total of 218 lessons in the 1972-73 version of the curriculum.

The decision to revise or delete a lesson was usually based on the percentage of students who branched out of it at the first checkpoint. These percentages ranged from 41% to 99%; there were 28 lessons from which 95% or more of the students branched out early. The amount of data was insufficient and, therefore, inconclusive for only three lessons and these occur at the very end of the course. This analysis revealed four general results that are not widely noted in the research literature on deaf education.

First, the 'directions' lessons were far easier than anticipated, given the general impression among deaf educators that deaf students experience difficulty in following directions. Some reasons for this result may be that the directions in these lessons and in the curriculum were easier to follow than those given in classroom instruction, that the directions given in the language arts CAI were more clearly communicated to students than the directions given in classroom instruction, or that deaf students have less difficulty following directions than generally supposed. More research is required to decide among these alternatives.

Second, although pronouns were generally far easier than anticipated, items on possessive pronouns were extremely difficult for the students. Specifically, possessive pronouns that differed in number (his boxes,

their box) and/or gender (his sister, her husband) from the nouns they modified were seldom completed correctly.

Third, copulas joining subjects with predicate complements that differed in number from their subjects were very difficult for the students. Copulas for items such as the following:

The house (is, are) blue and white.
The girls (seem, seems) lonely.

were seldom completed correctly.

Fourth, the students had very little trouble with contractions with the exception of 'I'm', which was far more difficult for the students than anticipated.

Many of the directions lessons were deleted. In all but two of the directions lessons 90% or more of the students branched out early. Most of the lessons asking for identification of letters were deleted because this task is seldom used in the course. Some directions lessons were kept because they cover several tasks in one lesson.

The following lessons were added:

3 lessons that provide practice with "who" and "what" questions;

4 lessons that require students to choose a correct pronoun to replace a noun or noun phrase;

5 lessons that require students to choose a correct noun or pronoun based on subject-verb agreement in number;

20 lessons that require students to identify and use correctly prepositions and prepositional phrases;

1 lesson that provides practice with "who," "what," "when," "where" questions;

2 lessons that require students to identify possessive noun phrases;

3 lessons that provide practice using contractions;

4 lessons that provide practice with the question transformation.

The review tests from the 1971-72 versions were deleted and replaced with review lessons that cover the revised content of the curriculum. These tests occur approximately every twelfth lesson.

THE LANGUAGE ARTS TEST

During the spring of 1971 an extensive search was made for a paper-and-pencil language test that would measure understanding of the language concepts covered in the language arts course. Few tests were found that were suitable for deaf students; none were suitable for the CAI curriculum. The Full-Range Picture Vocabulary Test (Ammons & Ammons, 1948) and the Peabody Picture Vocabulary Test (Dunn, 1959) are both fairly widely used in schools for the deaf, but they test receptive rather than expressive language and emphasize word meaning rather than word usage. The Illinois Communication Scale (Withrow, 1966) also tests receptive rather than expressive language, and because it requires film, it is expensive and complicated to administer. The Language Test part of the Tests of Basic Experiences (Moss, 1970) also tests receptive rather than expressive language; only about 30 items test word usage as opposed to word meaning. Language Skills for Americans (Stillwagon & Leake, 1952), the Language Facility Test (Daily, 1968), and the Language Usage Test developed at the Clarke School for the Deaf all test usage, punctuation, capitalization, and spelling. Only a small number of items in these three tests cover topics in the CAI language-arts course and many of the items are too difficult for the CAI student population. The Gates MacGintie Reading Tests (Gates & MacGintie, 1965), the Lee-Clark Reading Test (Lee & Clark, 1958), Primary Reading Profiles (Stroud, Hieronymus, &

McKee, 1957), the Kansas Primary Reading Test (Schrammel, Hoag, Humble, Robinson, & Wipf, 1935), and the Diagnostic Reading Test (1963) all test word recognition and reading comprehension rather than standard English usage. The language test developed at the California School for the Deaf at Berkeley (Marshall, 1962), the tests developed as part of the language curriculum, Generating English Sentences (Stokoe, Goldberg, Covington, LaRue, Womeldorf, & Bornstein, 1967), and the language tests developed at the Lexington School for the Deaf (Cooper, 1965) all call for constructed answers and provide no precise guidelines for correcting the test. The Picture Story Language Test (Myklebust, 1965) covers many of the same aspects of usage that are covered in the language arts curriculum, but the complexity of scoring this test makes it impractical to administer to a large number of students. The Illinois Test of Psycholinguistic Ability (McCarthy & Kirk, 1963) is used in several schools for the deaf and many teachers consider it a valuable diagnostic tool. Because it can only be administered individually, however, it was impractical for testing all of the students working on the CAI curriculum. The Stanford Achievement Test (Kelley, Madden, Gardner, & Rudman, 1966) and the Metropolitan Achievement Test (Durost, Bixler, Wrightstone, Prescott, & Balou, 1970) are being administered in many of the schools where the language arts course is being used. Again, however, these tests did not test the precise topics covered in the CAI course.

A set of tests were developed, therefore, to evaluate the language arts curriculum. Although there is a need for such tests in schools for the deaf, it was beyond the scope of the project to develop a broadly applicable language test. Instead, a criterion test that measures only

the objectives of the curriculum was written. The test items were modeled on the items in the course and were written for paper-and-pencil administration so that students who had not taken CAI could also take the test.

A preliminary version containing 78 questions was developed in May, 1971. This version was divided into eight subtests that covered the following topics: directions, parts of speech, noun phrases and double verbs, determiners, singular and plural noun forms, pronouns, subjects and predicates and adjective transforms.

The 1971-72 version of the test covered most of the topics taught in the first 200 lessons of the course. The test had 108 questions with one or two sample questions for each of 15 subtests.

Based on test and curriculum performance data gathered in 1971-72 and on the curriculum revision for 1972-73, the language arts test (LAT) was revised in the summer of 1972. The current version of the LAT provides eight questions on each of the 16 subtests listed in Table 2.

Three parallel forms of the LAT were constructed. The sample questions are identical on all forms and the items for each subtest are parallel in that three items for each morpheme position in the test are generated under fairly rigid syntactic and conceptual constraints and then assigned at random to the three subtest forms.

Specific directions for administering the LAT were written and include the correct answer to each sample question and set a time limit of 5 minutes for each subtest.

EVALUATION EXPERIMENT

In evaluating the language arts curriculum we emphasized variation in intensity of experimental treatment rather than simple comparisons of

Table 2

Subtests of Language Arts Test

Subtest	Title
1	Directions
2	Identification of nouns and pronouns
3	Identification of adjectives, determiners and possessive pronouns
4	Identification of verbs
5	Identification of noun phrases
6	Choose the correct determiner
7	Choose the correct form of the noun
8	Choose the correct pronoun
9	Choose the correct form of the verb
10	Choose the correct preposition
11	Identification of phrases that answer the question
12	Write singular and plural forms of nouns
13	Write forms of verbs
14	Make and expand contractions
15	Negative and adjective transforms
16	Possessive and question transforms

experimental and control groups. The purpose of the experiment was to measure the effect of varying number of language arts sessions on post-test scores. Each student was allowed to take only a specified number of 10-minute language arts sessions depending on which of five experimental groups he was assigned to. A student who signed on to the mathematics strands curriculum and who had not received sufficient language arts sessions, which depended on his experimental group and the number of school days in the experiment, was automatically given a language arts session. Analogously, a student who signed on to the language arts curriculum and who had received sufficient language arts sessions already was automatically given a mathematics strands session.

Data from the experiment were analyzed in two ways: first, in the context of traditional analysis of variance, and second, in the context of five models that attempted to account for posttreatment achievement in terms of pretreatment achievement and number of language arts sessions taken. Pre- and posttreatment achievement was measured by the language arts test described above and by standard tests, and the relationship of performance on the language arts test with performance on standard tests was estimated. The language-arts evaluation experiment was analogous in method and presentation to the mathematics strands evaluation experiment reported by Suppes, Fletcher, Zanotti, Lorton, and Searle (1973).

Models of Student Progress

Five models of student performance were used to characterize the relationship of posttreatment scores to pretreatment scores and number of language arts sessions taken. In all of these models T_{i1} denotes the pretreatment score of student i, T_{i2} denotes the posttreatment score

of student i, and N_i denotes number of language arts sessions taken by student i. Following standard notation $E(T_{i2})$ is the expected post-treatment score of student i.

Model I, Linear.

$$E(T_{i2}) = a_0 + a_1 T_{i1} + a_2 N_i \ .$$

In this model, the effect of pretreatment score and number of sessions on posttreatment performance is assumed to be linear.

Model II, Linear with interaction.

$$E(T_{i2}) = a_0 + a_1 T_{i1} + a_2 N_i + a_3 T_{i1} N_i \ .$$

In Model II, a linear effect of pretreatment score and number of sessions is assumed, but a linear effect from the interaction of pre-treatment score and number of sessions is also postulated.

Model III, Cobb-Douglas.

$$E(\ell n\ T_{i2}) = a_0 + a_1\ \ell n\ T_{i1} + a_2\ \ell n\ N_i \ .$$

Model III is based on a formulation of the Cobb-Douglas type (from econometrics), namely,

$$T_{i1} = a_0 T_i^{a_1} N_i^{a_2} \ .$$

This model is multiplicative and assumes "weighted interaction" in that a_1 and a_2 indicate the relative importance of pretreatment score and number of sessions, respectively, in accounting for change in post-treatment scores.

Model IV, Log quadratic.

$$E(T_{i2}) = a_0 + a_1 T_{i1} + a_2\ \ell n\ N_i + a_3(\ell n\ N_i)^2 + a_4(\ell n\ N_i)^3$$

In Model IV, the effect of the pretreatment score is assumed to be

linear, but the effect of number of sessions is assumed to be logarithmic, rather than linear. In order to explore this logarithmic assumption fully, second- and third-order terms in $\ell n\ N_i$ are included.

Model V, Exponential.

$$E(\ell n\ T_{i2}) = a_0 + a_1 N_i T_{i1} .$$

Model V is based on an exponential formulation, namely,

$$T_{i2} = a_o e^{a_1 N_i T_{i1}} .$$

In this model, the effect of number of sessions and pretreatment score may be strictly increasing or strictly decreasing depending on the sign of a_1. Pretreatment score and number of sessions are assumed to interact.

Subjects

As many students as possible from among those who were taking both the language arts and the mathematics strands CAI courses in 1972-73 and who were attending a residential school for the deaf in California, Oklahoma, or Texas were selected to participate as subjects in this experiment. The degree of hearing loss among the subjects selected for the experiment was essentially that adopted for admission standards by the schools, Generally, this loss averages at least 60 decibels in the better ear. Students who were enrolled for both language arts and mathematics strands CAI were usually of average or above-average ability relative to their school population.

Procedure

Of the 230 students selected as subjects for this experiment 45 were randomly assigned to Group I, 46 were randomly assigned to Group II, 46 to Group III, 47 to Group IV, and 46 to Group V. Random assignment

of the subjects to the treatment groups was stratified so that roughly the same number of subjects from each school were assigned to each of the five treatment groups.

Students assigned to Groups I, II, III, IV, and V were permitted 20, 45, 70, 95, and 120 language arts sessions. The maximum of 120 sessions was chosen by assuming that all students in the experiment were assigned two sessions per day, one for language arts and one for mathematics strands, that there were 80 school days in the experimental period, and that the probability of any student's actually taking an assigned session was .80. These assumptions yielded an estimated maximum of 128 sessions which was rounded down to 120.

Ordinarily, language arts sessions are terminated by students' request. The design of the present experiment required fixed, or at least deterministic, session lengths. For this reason all students in the experiment received 10-minute language arts sessions. A student participating in the experiment had no control over the type of session, mathematics strands or language arts, he received. Whether he signed on for strands or language arts, he was given a language arts session if he was eligible for one. Otherwise, he received a mathematics strands session.

Assignment of the required number of language arts sessions was spread across the experimental period in accordance with the following algorithm:

$$\text{if} \qquad NS_i < \left[\left(\frac{TS_i}{TD_i} \right) * D_i + 2 \right]$$

was true, then student i received a language arts session, otherwise, he received a mathematics strands session. In the algorithm,

NS_i = number of language arts sessions taken during the experimental period by student i,

TS_i = total number of language arts sessions student i was to receive during the experimental period,

TD_i = number of school days in the experimental period for student i,

D_i = number of school days student i has been in the experimental period,

and the brackets denote the next greatest integer.

The number of language arts sessions a student received was monitored daily. Teachers and proctors were encouraged to help students achieve the number of language arts sessions they were assigned. Teachers were urged not to give compensatory off-line work to students who were assigned low numbers of on-line sessions, and, in general, not to alter the classroom work of any student because of his participation in the experiment.

Subjects in the experiment were tested just before the experiment began and just after the experiment ended. Two of the three parallel forms of the IMSSS language-arts test were used for these test administrations. Also, end-of-year SAT scores for the Paragraph Meaning and Language subtests were obtained for as many of the subjects as possible. As a standard operating procedure, all three participating schools administered the SAT to all students enrolled at the end of each school year.

Analysis of Variance Results

Complete pre- and posttreatment data were obtained on the language arts test for 197 of the subjects in the experiment. However, many of these subjects had received sessions during the 1971-72 school year, and it was decided to limit the data analysis for the language-arts

evaluation experiment to the 85 subjects who had finished 26 or fewer sessions in 1971-72. A student who finished 26 or fewer sessions in the 1971-72 version of the language arts course would have received only directions lessons during that year and no CAI in the portions of the course that were directly relevant to standard English usage. This procedure yielded 21 subjects in experimental Group I, 14 subjects in Group II, 11 subjects in Group III, 18 subjects in Group IV, and 21 subjects in Group V. Means and standard deviations for number of sessions taken by subjects in the five groups are shown in Table 3. The averages for sessions taken are low for Group IV and Group V; however, the integrity of the experimental design was sufficiently maintained and the treatment groups sufficiently distinct to warrant proceeding with analysis of variance.

As a check on the random assignment of subjects to treatments, an analysis of variance was performed taking pretreatment LAT scores as dependent variables. The results of this analysis, with the average pretreatment LAT scores for each treatment group are shown in Table 4. As the table shows, the assignment of subjects to treatments was random with respect to subjects' pretreatment scores despite almost an 11-point difference in favor of Group I average scores over Group V average scores.

Analysis of variance taking the posttreatment LAT scores as dependent variables was performed at the end of the experiment. The results of this analysis with the average posttreatment LAT scores for the five treatment groups are shown in Table 5. These results were not statistically significant, and it was concluded that there is no functional

Table 3

Obtained Number of Students and Sessions for the Five Treatment Groups in the Experiment

Treatment group	Number of students obtained	Number of sessions assigned	Average number of sessions obtained	Standard deviation of sessions obtained
I	21	20	22.05	.97
II	14	45	46.21	1.12
III	11	70	68.91	2.26
IV	18	95	90.11	8.52
V	21	120	109.24	17.88

Table 4

Analysis of Variance for Pretreatment LAT Scores for the Five Treatment Groups

	Treatment group				
	I	II	III	IV	V
Sample size	21	14	11	18	21
Mean	73.95	61.86	60.45	56.33	63.05
Standard deviation	28.27	26.46	29.52	28.82	33.78

	Analysis of variance			
	Sum of squares	df	Mean square	F ratio
Between groups	3355.84	4	838.96	.949*
Within groups	70758.34	80	884.48	
Total	74114.19	84		

*Nonsignificant; $F_{.025}(4,80) = .12$ and $F_{.975}(4,80) = 3.01$.

Table 5

Analysis of Variance for Posttreatment LAT Scores for the Five Treatment Groups

	Treatment group				
	I	II	III	IV	V
Sample size	21	14	11	18	21
Mean	86.29	82.00	71.45	73.44	79.67
Standard deviation	26.37	24.08	31.13	28.71	31.41

Analysis of variance

	Sum of squares	df	Mean square	F ratio
Between groups	2423.92	4	605.98	.747*
Within groups	64888.13	80	811.10	
Total	67312.05	84		

*Nonsignificant; $F_{.025}(4,80) \approx .12$ and $F_{.975}(4,80) \approx 3.01$.

relationship between achievement tested by the LAT and number of language arts CAI sessions taken, at least with respect to the analysis of variance model used.

The null result could be explained by lack of reliability and/or validity in the LAT. An indication of the reliability of the LAT is given by the correlation of pre- and posttreatment scores in the 85-subject sample. This correlation was .91 with a standard error estimate (SEE) of 11.80 and an F ratio for significance of the regression of 400.78 ($F_{.99}(1,83) = 7.08$). Although a full-scale reliability study of the LAT is beyond the scope of this investigation, these pre- and post-treatment regression results indicate that the LAT is probably more reliable than many published tests.

Three regressions were examined for an indication of the content validity of the LAT. Scores on the LAT taken as independent variables were regressed onto number of lessons completed by the 85 students and against the SAT Paragraph Meaning and Language subtest scores of 62 subjects for whom these scores were available. Results of these regressions are shown in Table 6.

Achievement on a valid test for the language arts curriculum should be related to achievement in the curriculum, and this appears to be true for the LAT as evidenced by the significantly high correlation of .60 between lessons completed and LAT scores. The LAT evidently has some validity as a measure of achievement in the language arts course.

The SAT Paragraph Meaning subtest emphasizes the comprehension of connected discourse (Kelley, Madden, Gardener, & Rudman, 1966), and it is more characteristic of standard reading tests than of language arts

Table 6

LAT Scores Compared with Lessons Completed and SAT Subtest GP Scores

Dependent variables	Language arts correlation	Standard error of estimate	F-ratio	N
Lessons completed	.60	53.49	46.20**	85
SAT Paragraph Meaning	.21	.95	2.72	62
SAT Language	.73	.65	68.82**	62

**Significant at $p < .01$; $F_{.99}(1,83) \approx 7.08$; $F_{.99}(1,60) \approx 7.08$.

tests. Scores on a valid test of the language arts curriculum therefore should not necessarily correlate significantly with scores on the SAT Paragraph Meaning subtest, which is apparently true given the observed, nonsignificant correlation of .21 between LAT and Paragraph Meaning scores.

The SAT Language subtest comprises items on standard English usage, punctuation, capitalization, dictionary skills, and sentence sense (Kelley, et al., 1966). These items are characteristic of language arts tests, and scores on a valid test of the language arts curriculum should, therefore, correlate significantly with scores on the SAT Language subtest. This appears to be true given the observed, significant correlation of .73 between LAT and Language scores.

The data indicate that the LAT is reliable and a valid test of achievement for the language arts curriculum. However, the correlation between the LAT and the SAT Paragraph Meaning subtest was greater than the correlation between the LAT and the number of language-arts CAI lessons completed. In some sense, then, the LAT may be "more valid" as a test of general language-arts knowledge than of achievement in the language arts curriculum.

As a final effort to find a functional relation between language arts sessions taken and a measure of achievement, analysis of variance was performed using the five treatment groups and taking the SAT Language GP scores as dependent variables. Results from this analysis are shown in Table 7. The F-ratio is significant at $p < .05$. Because the F-ratio is smaller than chance, however, a reasonable interpretation of the data is that the results are due to a violation of the analysis of variance

Table 7

Analysis of Variance for Posttreatment SAT Language GP for the Five Treatment Groups

	Treatment group				
	I	II	III	IV	V
Sample size	15	10	8	8	16
Mean	3.54	3.65	3.51	3.51	3.71
Standard deviation	.79	.71	1.01	.63	1.38

	Analysis of variance			
	Sum of squares	df	Mean square	F ratio
Between groups	.449	4	.112	.119*
Within groups	53.816	57	.944	
Total	54.265	61		

*Significant ($p < .05$); $F_{.975}(4,57) = 3.13$ and $F_{.025}(4,57) = .12$.

assumption rather than to an effect due to the treatment groups. In this case, the assumption of homoscedasticity was violated and the treatment group variances differ significantly.

An analysis of variance was performed on posttreatment SAT Paragraph Meaning GP scores. The results of this analysis are shown in Table 8. No significant effects on the Paragraph Meaning GP scores due to the five treatment groups were evident.

Performance Models Results

Parameters were generated for the five models described above taking, first, LAT posttreatment scores and, second, SAT Language subtest scores as dependent variables. Because the number of lessons completed by the students correlated significantly with LAT and Language scores, an additional model, Model VI, was added:

$$E(T_2) = a_0 + a_1T_1 + a_2N + a_3L ,$$

where T_1, T_2, and N are defined as before and L is the number of lessons completed. Presumably, the better students both completed more lessons and scored higher on the LAT and Language tests. However, if the a_2 sessions parameter contributes significantly to Model VI after the contributions from the pretreatment LAT scores and number of lessons completed have been included in the model, then it is reasonable to conclude that there is at least some effect on the dependent variables from number of sessions taken.

The models with their generated parameters are shown in Tables 9 and 10. Table 9 shows the models fitted to LAT scores taken as dependent variables, and Table 10 shows the models fitted to SAT Language GP scores

Table 8

Analysis of Variance for Posttreatment SAT Paragraph Meaning GP for the Five Treatment Groups

	Treatment group				
	I	II	III	IV	V
Sample size	15	10	8	13	16
Mean	4.12	3.71	4.25	4.17	4.43
Standard deviation	1.13	.99	.72	.88	.97

	Analysis of variance			
	Sum of squares	df	Mean square	F ratio
Between groups	3.292	4	.823	.875*
Within groups	53.635	57	.941	
Total	56.927	61		

*Nonsignificant; $F_{.975}(4,57) = 3.13$ and $F_{.025}(4,57) = .12$.

Table 9

Six Models of Student Performance with LAT Scores as Dependent Variables

---

Model I: $E(T_2) = a_0 + a_1T_1 + a_2N$

$a_0 = 23.975$, $a_1 = .867$, $a_2 = .000$*

Multiple correlation = .910

Model II: $E(T_2) = a_0 + a_1T_1 + a_2N + a_3T_1N$

$a_0 = 25.427$, $a_1 = .844$, $a_2 = -.020$,* $a_3 = .000$*

Multiple correlation = .910

Model III: $E(\ell n\ T_2) = a_0 + a_1\ \ell n\ T_1 + a_2\ \ell n\ N$

$a_0 = 2.161$, $a_1 = .546$, $a_2 = -.014$*

Multiple correlation = .800

Model IV: $E(T_2) = a_0 + a_1T_1 + a_2(\ell n\ N) = a_3(\ell n\ N)^2 + a_4(\ell n\ N)^3$

$a_0 = -35.841$, $a_1 = .871$, $a_2 = 30.815$,* $a_3 = -3.885$,* $a_4 = .000$*

Multiple correlation = .911

Model V: $E(\ell n\ T_2) = a_0 + a_1T_1N$

$a_0 = 4.040$, $a_1 = .0001$

Multiple correlation = .476

Model VI: $E(T_2) = a_0 + a_1T_1 + a_2N + a_3L$

$a_0 = 30.918$, $a_1 = .684$, $a_2 = -.140$, $a_3 = .125$

Multiple correlation = .927

Table 9 (cont'd)

Note:--T_1 = pretreatment LAT

T_2 = posttreatment LAT

N = number of sessions

L = number of lessons.

*Does not contribute significantly to the model.

Table 10

Six Models of Student Performance with SAT Language Subtest Scores as Dependent Variables

---

Model I: $E(T_2) = a_0 + a_1T_1 + a_2N$

$a_0 = 1.549$, $a_1 = .030$, $a_2 = .001$*

Multiple correlation = .806

Model II: $E(T_2) = a_0 + a_1T_1 + a_2N + a_3T_1N$

$a_0 = 1.370$, $a_1 = .032$, $a_2 = .003$,* $a_3 = .000$*

Multiple correlation = .807

Model III: $E(\ell n\ T_3) = a_0 + a_1\ \ell n\ T_1 + a_2\ \ell n\ N$

$a_0 = -.772$, $a_1 = .465$, $a_2 = .000$*

Multiple correlation = .791

Model IV: $E(T_2) = a_0 + a_1T_1 + a_2\ (\ell n\ N) + a_3\ (\ell n\ N)^2 + a_4\ (\ell n\ N)^3$

$a_0 = -1.406$, $a_1 = .030$, $a_2 = 1.516$,* $a_3 = -.186$,* $a_4 = .000$*

Multiple correlation = .809

Model V: $E(\ell n\ T_2) = a_0 + a_1T_1N$

$a_0 = 1.081$, $a_1 = .0004$

Multiple correlation = .470

Model VI: $E(T_2) = a_0 + a_1T_1 + a_2N + a_3L$

$a_0 = 1.608$, $a_1 = .028$, $a_2 = -.0003$,* $a_3 = .001$*

Multiple correlation = .807

Table 10 (cont'd)

Note:--T_1 = pretreatment SAT Language GP

T_2 = posttreatment SAT Language GP

N = number of sessions

L = number of lessons.

*Does not contribute significantly to the model.

taken as dependent variables. The best model of student performance in Table 9 is Model VI, which accounts for 86% of the LAT score variance and which is a "straightforward" linear model in that it includes no interaction, exponential, or logarithmic terms. It should be noted, first, that the regression coefficient for number of sessions taken contributes significantly to Model VI and, second, that the coefficient is negative. Evidently, for all levels of pretreatment achievement measured by the LAT, number of sessions taken enters the model as a "rate" variable; the fewer sessions a student needs to complete a given number of lessons, the higher his LAT posttreatment score. Because the regression coefficient for number of lessons completed does contribute significantly to Model VI, which also takes into account LAT pretreatment scores, it is reasonable to conclude that a student who is required to complete more lessons, rather than more sessions, will, as a result, score higher on the posttreatment LAT.

All the dependent variable variance accounted for by the models in Table 10 appears to be due to the simple linear relationship between pretreatment LAT and the SAT Language subtest. In Model VI it should be noted that number of lessons completed does not contribute significantly to SAT Language score variance after the contribution of pretreatment LAT scores is included in the model. This finding obtains from the analysis despite the significant correlation of lessons completed with Language scores when pretreatment LAT scores are taken into account.

Finally, it is notable that the correlation between pretreatment LAT scores and the SAT Language GP scores is greater than the correlation

between posttreatment LAT scores and Language GP scores. The pretreatment LAT accounted for 66% of the variance in Language GP scores compared with 53% for the posttreatment LAT. It is difficult to explain this result. However, because of the significant correlation between number of lessons completed and the language scores, it is not reasonable to conclude that the language arts curriculum had a deleterious effect on the Language GP scores.

TEACHING STRATEGIES EXPERIMENTS

Three issues that commonly arise in the design of tutorial CAI curriculum are the following: the utility of providing "tailored" wrong answer messages in response to specific, anticipated wrong answers compared with a simple statement such as NO or WRONG in response to all wrong answers; the utility of providing for second and third guesses after a student initially responds incorrectly to an item compared with only one consecutive trial per item; the utility of requiring a student to respond correctly after he has made an incorrect response to an item and has been told the correct answer. Accordingly, three experiments were run in 1972-73 in the context of the language arts curriculum in an attempt to resolve these three issues.

Subjects

All CAI language arts students in three residential schools and five day schools for the deaf participated in the three experiments. The students were not aware of their assignment to the three experiments. Characteristics of these students were essentially the same as the characteristics of the students who participated in the evaluation experiment described earlier. In general, deaf day school students are

slightly further behind school norms than the deaf residential school students, but there was no evidence that the particular students chosen as subjects in these experiments were of either lower or higher ability than students who participated in the evaluation experiment. Also, in accord with the procedure followed for the evaluation experiment, data from students who received more than 26 lessons in 1970-71 and/or 1971-72 were excluded. Complete data were obtained for 138 students who then comprised the subject population for these three experiments.

Procedure

Each student who participated as a subject was assigned independently and at random to one of two groups in each of three experiments. These assignments were made automatically by computer program when a subject began the language arts curriculum. Pretreatment and posttreatment LAT scores were recorded for each subject in the experiments.

Experiment 1 comprised two treatment groups. One group received programmed correction messages that were tailored for specific, anticipated wrong answers. About half of the exercises in the curriculum include one or more of these programmed correction messages. Members of the second group in Experiment 1 did not receive these messages; they were told only that their answer was WRONG. In accordance with their Experiment 2 treatment group, both Experiment 1 groups received the correct answer after the wrong answer response was given.

Experiment 2 comprised two treatment groups. One group was allowed three trials per exercise, the second group was allowed only one trial per exercise. The members of the first Experiment 2 group received either a programmed correction or a WRONG, depending on their Experiment 1

treatment group, after the first and second trials on an exercise. They were not given the correct answer explicitly until the third trial unless the correct answer was part of a programmed correction message. The correct answer was rarely included in these correction messages.

Experiment 3 comprised two treatment groups. In one group, the correct answer was given explicitly, but students were not required to type the correct answer after it was given. In the second group, members were required to type the correct answer after it was explicitly given following a wrong response.

The two groups under each of the three experiments yielded eight possible treatments for any given member of the 138 student population. The experimental treatments and the number of students randomly assigned by the computer program to them are summarized by Table 11.

Results and Discussion

The LAT was administered at the beginning of the 1972-73 school year and at the end of the school year to all students in schools for the deaf who took the language arts CAI curriculum. Care was taken to assure that each subject received two different forms of the LAT on these two test administrations.

Results from the pretreatment LAT administration for subjects in each of the two treatment groups in each of the three teaching strategies experiments are shown in Table 12. Because of the large differences between the mean LAT pretreatment scores of each pair of treatments, analysis of covariance was used in examining the posttreatment LAT scores. Results from the posttreatment administration of the LAT adjusted for the pretreatment LAT which was used as a covariate are shown in Table 13.

Table 11

Subjects Assigned to Treatments in the Teaching Strategies Experiments

Treatment group	Experiment 1: 0 for tailored wrong answer messages, 1 for standard wrong answer messages	Experiment 2: 0 for 3 trials, 1 for 1 trial	Experiment 3: 0 for no correct response required after a wrong answer, 1 for correct response required after a wrong answer	Number of subjects assigned
1	0	0	0	23
2	1	0	0	14
3	0	1	0	22
4	1	1	0	15
5	0	0	1	15
6	1	0	1	19
7	0	1	1	12
8	1	1	1	18
Total assigned to Group 0	72	71	74	
Total assigned to Group 1	66	67	64	
Total assigned	138	138	138	

Table 12

Precreatment LAT Scores for the Three Teaching Strategies Experiments

Experiment	Treatment group	Mean LAT scores	SD LAT scores	N	t for differences in means
1	0 (tailored wrong answer messages)	61.58	25.57	72	-1.29
	1 (standard wrong answer messages)	67.00	23.44	66	
2	0 (3 trials)	67.53	24.69	71	1.66
	1 (1 trial)	60.61	24.25	67	
3	(no correct response required)	59.58	23.97	74	-2.40*
	1 (correct response required)	69.48	24.50	64	

*Significant, $p < .05$. $t_{.975}(138) \approx 1.98$.

Table 13

Adjusted Posttreatment LAT Scores for the Three Teaching Strategies Experiments[a]

Experiment		Mean LAT scores	SD LAT scores	N	t
1	0 (tailored wrong answer messages)	78.15	20.56	72	-.66
	1 (standard wrong answer messages)	80.44	20.33	66	
2	0 (3 trials)	84.27	18.63	71	3.04**
	1 (1 trial)	73.93	21.28	67	
3	0 (no correct response required)	75.70	20.61	74	-2.23*
	1 (correct response required)	83.34	19.48	64	

[a]These data are adjusted to accord with pretreatment LAT scores used as covariates.

*Significant, $p < .05$. $t_{.975}(134) \approx 1.98$.

**Signiricant, $p < .01$. $t_{.995}(134) \approx 2.62$.

Experiment 1. As Table 13 shows, there was no practical or significant difference in LAT achievement between subjects who received tailored wrong answer messages and those who received standard wrong answer messages. Considerable time and concomitant expense are ordinarily allocated to constructing tailored wrong answer messages for tutorial CAI. This was certainly the case for the language arts curriculum. A check of the most frequently given wrong answers revealed that the wrong answer messages written for the language arts curriculum were generally appropriate. The subjective impression of the authors was that revising the set of tailored wrong answer messages used would not significantly affect the Experiment 1 results.

Experiment 2. Posttreatment LAT scores revealed significantly superior results for the three-trial treatment group over the one-trial treatment group. Evidently the opportunity to try again provided significant benefits for students taking the language arts curriculum. This result seems to support a hypothesis-generation theory of learning. Under such a theory, a subject who is told that an answer he gave was wrong receives very little information; it is far more informative to him to receive positive corroboration of a hypothesis that he has generated.

Experiment 3. Posttreatment LAT scores indicated a positive, significant effect from requiring subjects to respond correctly after making a wrong answer and being told the correct answer. This result is intuitively reasonable, because a subject who is responding rapidly in the typical context of CAI might easily ignore answers that fail to accord with his understanding. For that matter, the Experiment 3

results imply that subjects who were not required to respond correctly before continuing past a problem, for whatever reason, ignored some of the correct responses.

ITEM ANALYSIS

The intent of this analysis was to identify useful dimensions of difficulty that affect performance on language arts items taken by deaf students. Three different item classifications were used. Items were classified by the specific course objectives listed earlier, by the required exercise tasks, and by the required formats for correct answers.

Subjects

The responses of 31 hearing-impaired students, 14 boys and 17 girls, who completed no language arts lessons in 1970-71, fewer than 27 lessons in 1971-72, and at least 150 lessons in 1972-73, were selected for the item analysis of the 1972-73 language arts curriculum. Only the initial responses of each subject to each item were considered in the analysis. The ages of the subjects ranged from 12 years 6 months to 19 years 5 months with an average age of 16 years 3 months. All but one of the subjects were selected from residential schools for the deaf. The characteristics of these subjects were the same as those of subjects selected for the evaluation and teaching strategies experiments. Hearing loss of each subject averaged at least 60 decibels in the better ear.

The language-arts curriculum responses of 12 hearing, American Indian students, three boys and nine girls, were analyzed in a parallel investigation. These students attended a Bureau of Indian Affairs (BIA) school on a reservation in New Mexico. It is difficult to characterize

American Indian students other than to note that they are generally ill equipped to cope with the values and content of middle-class Anglo education. Many of these students speak an Indian language in their homes, and many have adopted the rich culture of their tribe long before entering a BIA school. They typically score below grade level on most standardized tests of academic achievement. The ages of the Indian students ranged from 9 years 11 months to 13 years 3 months with an average age of 11 years 3 months. All the Indian subjects completed no language arts lessons in 1970-71, fewer than 27 lessons in 1971-72, and more than 150 lessons in 1972-73. Again, only the initial responses of each subject to each item were considered in the analysis.

Results

Course objectives. Because all subjects had finished only 150 of the 218 lessons in the curriculum, only 28 of the 42 specific objectives listed earlier were included in the analysis. Notably, none of the specific objectives under the fourth general course objective--performing specified transformations on grammatical structures--could be included in the analysis. The objectives are listed in abbreviated form in Table 14. Table 14 also lists the number of items included under each objective and, for deaf and Indian subjects, the difficulty ranking (Rank) and the proportion of correct answers for each objective (PCA). Kendall's rank coefficient was calculated for the difficulty rankings of the objectives in the two sets of data. This statistic indicated that the two difficulty rankings were independent ($r = .16$, $S = 60$, $N = 28$).

The relative difficulties of the general course objectives concerned with directions, grammatical categories, grammatical structures, and

Table 14

Number of Items (N), Difficulty Ranking (Rank), and Percentage of Correct Answers (PCA) for 28 Specific Objectives

			Deaf Subjects		Indian Subjects	
	Objective	N	Rank	PCA	Rank	PCA
1a	Type specified letters	20	24	.801	9	.936
1b	Type specified words	39	17	.845	7	.944
1c	Copy specified phrase	5	2	.908	23	.864
1d	Type specified number	15	26	.794	3	.970
2a	Identify nominative or objective nouns	55	23	.812	20	.881
2b	Identify noun phrases	11	21	.833	21	.878
2c	Identify determiners	84	20	.836	14	.916
2d	Identify vowels	12	13	.860	10	.928
2e	Identify nominative and objective noun phrases	77	27	.755	27	.774
2f	Identify singular and plural nouns	17	28	.650	28	.764
2g	Identify tense marked verbs	59	7	.889	26	.795
2j	Identify nominative and predicate adjectives	35	25	.798	25	.842
2k	Identify subjects and predicates	72	10	.872	24	.853
2l	Identify pronouns	35	19	.837	12	.918
2m	Identify answering noun phrases	70	16	.851	17	.910
2n	Identify prepositions	20	8	.884	13	.917

Table 14 (cont'd)

			Deaf Subjects		Indian Subjects	
		N	Rank	PCA	Rank	PCA
2o	Identify prepositional phrases	77	5	.899	19	.893
3a	Supply plural and singular nouns	71	15	.852	18	.898
3b	Indicate singular and plural noun phrases	76	3	.908	11	.921
3c	Supply gender marked verbs	63	4	.905	8	.939
3d	Indicate singular and plural subjects	47	11	.865	22	.872
4a	Supply "a" or "an"	23	14	.858	16	.910
4b	Choose determiner for number	44	18	.837	15	.913
4c	Choose pronoun to replace noun phrase	99	9	.880	5	.951
4d	Choose verb inflection for number	147	12	.862	6	.945
4e	Choose inflection of "to be"	41	-	.917	1	.978
4g	Choose noun and pronoun for number	59	22	.833	4	.957
4h	Choose preposition	39	6	.890	2	.975

grammatical units were investigated by categorizing each specific objective under one of these general objectives and by calculating the Kruskall-Wallis multisample test statistics, H, for the four sets of difficulty rankings. Results from this analysis for both deaf and Indian subjects are shown in Table 15. The four general objectives were significantly related to the item difficulty rankings for the Indian students ($p < .05$), but not for the deaf students.

Exercise Tasks

There were four dimensions of classification by exercise task.

1. Instructions given or no instructions given. This dimension distinguished exercises that occur early in lessons for which the instructions are printed or repeated, from exercises that occur later in lessons when it was assumed the student had them well in mind.

2. Instance (number) or instance (text) or concept. This dimension distinguished exercises in which the student must answer with an instance of a concept from exercises in which the student must answer with a concept based on a given instance. When concepts are answers they are always abbreviated. Some instances are numbered so the student can reply with number(s) associated with the text--instance (number)--rather than with the actual text of the instances--instance (text).

3. Recognition or construction (explicit basis) or construction (implicit basis). This dimension distinguished exercises in which the answer is printed in the exercise display--recognition--from exercises in which the answer does not appear in the display--construction. The construction (explicit basis) and construction (implicit basis) dimensions distinguished between degrees of explicitness in the exercise

Table 15

Comparison of Mean Difficulty Rankings for the Four General Course Objectives

	Number of specific objectives	Mean rank for deaf subjects	Mean rank for Indian subjects
Directions	4	17.25	10.50
Recognize categories	13	17.08	19.69
Recognize and supply structures	4	8.25	14.75
Select appropriate units	7	11.71	7.00
Kruskall-Wallis H		4.83	11.95*

*Significant, $p < .05$; $H_{.95}(3) = 9.35$.

directions. In construction (explicit basis) a form, but not the correct form, of the correct answer text is given; in construction (implicit basis) no form of the correct answer is given explicitly.

4. Usage or definition. This dimension distinguished exercises in which the answer is derived on the basis of an implicit rule of usage taught inductively in the curriculum from exercises in which the answer is derived from the definition of a grammatical category.

Given 2 times 3 times 3 times 2 possibilities, there would be 36 categories under this task classification scheme if it were not for the following combinations that do not occur: concept-construction tasks, concept-usage tasks, or instance (number)-construction tasks. Eighteen categories of exercise tasks were left plus one category labeled "Giveaway," which included items in which the correct answer is explicitly given to the student. Two categories of exercise tasks do not occur in the first 150 lessons of the curriculum, so there are 17 tasks included in the present analysis. These tasks are listed in Table 16. The table also lists the number of items included under each task (N) and, for deaf and Indian students, the difficulty ranking (Rank) as well as the proportion of correct answers for each task (PCA). Kendall's rank coefficient was calculated for the difficulty rankings of the two sets of data. This statistic indicated that the difficulty rankings of exercise tasks for the deaf and Indian subjects were similar ($p < .05$) or, more precisely, not independent ($r = .37$, $S = 50$, $N = 17$).

Four more general categorizations of the exercise tasks were also investigated. These categorizations were derived from the four dimensions of exercise task classification listed earlier. Table 17 shows

Table 16

Number of Items (N), Difficulty Ranking (Rank), and Percentage of Correct Answers (PCA) for 17 Exercise Tasks

		Deaf Subjects		Indian Subjects	
Task	N	Rank	PCA	Rank	PCA
Instruction, number, recognition, usage	25	14	.841	15	.884
Instruction, number, recognition, definition	248	16	.810	17	.829
Instruction, text, recognition, usage	208	10	.867	5	.946
Instruction, text, recognition, definition	246	17	.810	16	.875
Instruction, concept, recognition, definition	52	9	.873	12	.907
Instruction, text, construction explicit, definition	72	7	.878	9	.925
Instruction, text, construction implicit, usage	12	15	.818	4	.950
No instruction, number, recognition, usage	8	8	.873	14	.896
No instruction, number, recognition, definition	24	13	.851	7	.942
No instruction, text, recognition, usage	89	6	.897	10	.924
No instruction, text, recognition, definition	225	11	.867	3	.951
No instruction, concept, recognition, definition	113	5	.904	8	.927

Table 16 (cont'd)

Task	N	Deaf Subjects Rank	Deaf Subjects PCA	Indian Subjects Rank	Indian Subjects PCA
No instruction, text, construction explicit, usage	73	4	.905	13	.900
No instruction, text, construction explicit, definition	5	2	.941	2	.955
No instruction, text, construction implicit, usage	54	12	.865	11	.911
No instruction, text, construction implicit, definition	10	3	.934	6	.945
Giveaway	3	1	.941	1	.971

Table 17

Comparison of Mean Difficulty Rankings for the Four Dimensions of Exercise Tasks

	Number of tasks	Mean rank for deaf subjects	Mean rank for Indian subjects
Instructions	7	12.57	11.14
No instructions	9	7.11	8.22
Mann-Whitney U		3.00*	13.00
Instance-number	4	12.75	13.25
Instance-text	10	8.70	7.90
Concept	2	14.00	20.00
Kruskal-Wallis H		15.40*	16.34*
Recognition	10	10.90	10.70
Construction-Explicit	3	4.33	8.00
Construction-Implicit	3	10.00	7.00
Kruskal-Wallis H		17.14*	14.47*
Usage	7	9.86	10.29
Definition	9	9.22	8.89
Mann-Whitney U		25.00	19.00

*Significant, $p < .01$; $U_{.99}(7,9) = 8$; $H_{.99}(2) = 10.6$.

the mean difficulty rankings associated with each of these classification dimensions for both groups of subjects. As Table 17 indicates, three of the four classification dimensions were significantly related to exercise task difficulties. The presence or absence of instructions was related to the exercise-task difficulty rankings for deaf subjects ($p < .01$) but not for Indian subjects. Requiring instance-number, instance-text, or concept and requiring recognition, construction-explicit, or construction-implicit were both significantly related to the exercise-task difficulty rankings for both deaf and Indian subjects ($p < .01$).

Correct answer format. There were three dimensions of classification based on correct answer formats.

1. Word or letter or number or abbreviation. There was some "nesting" under this dimension: word was classified as 1-, 2-, 3-, or 4-word strings; letter was classified 1-, 2-, or 3-letter strings; and number was classified as 1-, 2-, 3-, 4-, or 5-number strings. Abbreviations presented a problem in that they could reasonably be classified as single letters, multiple letters, or single words. It was decided that abbreviations would confuse the single letter, multiple letter, or single word results, and they were treated separately in the exercise-format data analyses.

2. Sequence or no sequence. In some instances, the sequence of a multiple word, multiple letter, or multiple-number response is important; in some instances sequence is not important. This dimension distinguished between these instances.

3. Copied or constructed. If the elements for the correct answers are all present in the item display, the correct answer was classified as copied. Otherwise, it was classified as constructed.

Classified in this way, 18 correct answer formats occurred in the language arts curriculum. Sufficient data were available to include 16 of these formats in the present analysis. These formats are listed in Table 18, which also lists the number of items included under each format (N) and, for deaf and Indian students, the difficulty ranking of each format (Rank) and the proportion of correct answers for the formats (PCA). Kendall's rank coefficient, which was calculated for the difficulty rankings from both sets of data, indicated that the two rankings were independent ($r = .30$, $S = 36$, $N = 16$).

Discussion

The intent of the item analysis was descriptive, and it is difficult to say if useful dimensions of problem difficulty have been identified. The lack of agreement between the deaf and Indian subjects on the three item difficulty rankings clearly indicates that different populations of students were involved in this investigation, and that the tasks posed by the items to the deaf students were quite different from the tasks they posed to the Indian students. The authors' subjective impression was that the lack of intuitive clusters of rankings in all three classification schemes indicated that more precise experimentation will be necessary to reveal true and cognitively meaningful dimensions of problem difficulty appropriate for the populations investigated here.

Table 18

Number of Items (N), Difficulty Ranking (Rank), and Percentage of Correct Answers (PCA) for 16 Correct Answer Formats

		Deaf Subjects		Indian Subjects	
Format	N	Rank	PCA	Rank	PCA
One word, copied	597	7	.862	2	.935
Two words, no sequence, copied	16	10	.830	12	.837
Three words, no sequence, copied	1	1	.926	9	.882
Two words, sequence, copied	60	14	.787	15	.825
Three words, sequence, copied	18	3	.885	3	.928
One word, constructed	150	5	.872	4	.923
One letter, copied	15	11	.808	1	.950
Two letters, no sequence, copied	8	13	.792	8	.902
One number, copied	133	9	.835	11	.869
Two numbers, no sequence, copied	51	16	.749	13	.831
Three numbers, no sequence, copied	7	15	.770	10	.871
Two numbers, sequence, copied	74	8	.858	14	.830
Three numbers, sequence, copied	92	4	.873	7	.904

Table 18 (cont'd)

Format	N	Deaf Subjects		Indian Subjects	
		Rank	PCA	Rank	PCA
Four numbers, sequence, copied	26	12	.804	16	.807
Five numbers, sequence, copied	6	6	.871	5	.918
Abbreviation	210	2	.886	6	.909

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Footnotes

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APPENDIX A

Third Grade Vocabulary List for the Language Arts Course

able ADJ.
about ADV.
across PREP.
act V.
afraid ADJ.
after PREP.
afternoon N.
again ADV.
against PREP.
all DET.
almost ADV.
alone ADJ.
along PREP.
also ADV.
always ADV.
am V.
and CONJ.
angry ADJ.
another DET.
any DET.
apple N.
are V.
arm N.
around PREP.
asleep ADJ.
as ADV.
ate V.
at PREP.
aunt N.
away ADV.
a DET.

baby N.
back ADV.
bad ADJ.
bag N.
ball N.
bank N.
bang INT.
basket N.
bear N.
beautiful ADJ.
beat V.
because CONJ.
bed N.
before PREP.
began V.
behind PREP.
below PREP.
bell N.
best ADJ.
better ADJ.
between PREP.
be V.
bicycle N.
big ADJ.
bigger ADJ.
birthday N.
bite V.
bit V.
black ADJ.
blanket N.
blew V.
block N.
blue ADJ.
boat N.
both DET.
bottom N.
bought V.
box N.
boy N.
brave ADJ.
bread N.
break V.
breakfast N.
bring V.
bright ADJ.
brown ADJ.
brook N.
brother N.
broken V.
brought V.
built V.
busy ADJ.
business N.
but CONJ.
butter N.
by PREP.

cage N.
call V.
came V.
can V.
candy N.
cart N.
car N.
carry V.
care V.
castle N.
cat N.
catch V.
caught V.
cheese N.
children N.
chief N.
circus N.
city N.
clean ADJ.
clever ADJ.
climb V.
close V.
clop INT.
clock N.
clothes N.
cloud N.
cloth N.
coat N.
cold ADJ.
come V.
coming V.
cool ADJ.
corn N.
corner N.
course ID.
could V.
country N.
cow N.
cried V.
crowd N.
cry V.
cup N.
cut V.

danger N.
dark ADJ.
day N.
deer N.
deep ADJ.
did V.
different ADJ.
dig V.
dinner N.
does V.
dog N.
door N.
down ADV.
do V.
dress N.
drink V.
drive V.
dry ADJ.
duck N.

easy ADJ.
eat V.
edge N.
egg N.
eight DET.
either CONJ.
elephant N.
else ID.
empty ADJ.
end N.
engine N.
enough ADV.
ever ADV.
every DET.
even ADV.
evening N.

face N.
fall V.
family N.
farm N.
far ADV.
farmer N.
fast ADV.
faster ADV.
fat ADJ.
father N.
feather N.
feed V.
feet N.
feel V.
fell V.
felt V.
fence N.
few DET.
field N.
fill V.
fine ADJ.
find V.
finger N.
first ADJ.
fire N.
fish N.
five DET.
flag N.
flew V.
fly V.
foot N.
food N.
foolish ADJ.
for PREP.
forest N.
forth ID.
four DET.
found V.
free ADJ.
fresh ADJ.
friendly ADJ.
friend N.
from PREP.
front N.
fruit N.
full ADJ.
fun N.
funny ADJ.

garden N.
gate N.
gave V.
get V.
give V.
glad ADJ.
glass N.
goat N.
going V.
gone V.
good ADJ.
got V.
go V.
grass N.
gray ADJ.
grandmother N.
grandfather N.
green ADJ.
grew V.
great ADJ.
ground N.
grow V.

had V.
hair N.
happy ADJ.
hard ADJ.
has V.
hat N.
have V.
hear V.
head N.
heavy ADJ.
heard V.
held V.
help V.
hello INT.
hen N.
her DET.
here ADV.
he PRO.
hide V.
high ADJ.
hill N.
him PRO.
himself PRO.
his DET.
hit V.
hole N.
hold V.
home N.
hope V.
horse N.
hospital N.
hot ADJ.
house N.
how ADV.
huge ADJ.
hunt V.
hungry ADJ.
hurry V.
husband N.

idea N.
if CONJ.
important ADJ.
indian N.
into PREP.
in PREP.
is V.
its DET.
it PRO.
i PRO.

job N.
jump V.
jumped V.
just ADV.

keep V.
kept V.
king N.
kind N.
kitten N.
kitchen N.
knew V.
know V.

lake N.
land N.
last ADJ.
late ADJ.
laughed V.
lay V.
lazy ADJ.
led V.
left V.
let V.
letter N.
life N.
lift V.
light N.
line N.
lion N.
listen V.
little ADJ.
log N.
long ADJ.
loose ADJ.
lost ADJ.
lose V.
lot ID.
loud ADJ.
love V.
low ADJ.
lucky ADJ.
lunch N.

machine N.
made V.
make V.
man N.DET.
march V.
matter N.
may V.
meat N.
mean V.
meet V.
men N.
met V.
me PRO.
middle N.
might V.
milk N.
minute N.
mind V.
mirror N.
miss V.
money N.
more DET.
most PRO.
mother N.
mouse N.
mouth N.
mountain N.
move V.
mrs N.
mr N.
much ADJ.
must V.
my DET.

near PREP.
nearer PREP.
neck N.
need V.
never ADV.
new ADJ.
next ADJ.
nice ADJ.
night N.
noise N.
north N.
nose N.
not ADV.
nothing PRO.
now ADV.
no DET.

oak N.
off ADV.
office N.
often ADV.
of PREP.
oh INT.
old ADJ.
once ADV.
one DET.
only ADJ.
on PREP.
open V.
or CONJ.
other DET.
our DET.
out ADV.
over PREP.
owl N.
own ADJ.

pail N.
paint V.
palace N.
paper N.
park N.
part N.
parade N.
path N.
paw N.
pay V.
pen N.
pencil N.
penny N.
people N.
perhaps ADV.
pet N.
picnic N.
pie N.
pilot N.
pile N.
pink ADJ.
play V.
place N.
please INT.
policeman N.
polite ADJ.
pole N.
poor ADJ.
pop V.
porch N.
pretty ADJ.
prince N.
princess N.
prize N.
promise N.
proud ADJ.
pull V.
pumpkin N.
put V.

queen N.
quiet ADJ.
quick ADJ.
quite ADV.
quickly ADV.

rabbit N.
race N.
rain N.
ran V.
rang V.
read V.
really ADV.
ready ADJ.
real ADJ.
red ADJ.
remember V.
rest N.
ride V.
right ADJ.
ring N.
river N.
road N.
rode V.
roof N.
room N.
rope N.
round ADJ.
row N.
run V.
running V.

sad ADJ.
safe ADJ.
said V.
salt N.
same ADJ.
sang V.
sat V.
saturday N.
save V.
saw V.
say V.
scare V.
school N.
sea N.
seat N.
second ADJ.
secret N.
see V.
seen V.
sell V.
sent V.
send V.
set V.
seven DET.
several DET.
shall V.
she PRO.
short ADJ.
shot V.
shock V.
shoulder N.
shop V.
should V.
shut V.
side N.
sight N.
silver N.
silly ADJ.
sing V.
sister N.
sit V.
six DET.
sky N.
sleep V.
slowly ADV.
small ADJ.
smile V.
smoke N.
snow N.
soft ADJ.
some DET.
something PRO.
song N.
soon ADV.
sorry ADJ.
soup N.
sound N.
so ADV.
spend V.
splash V.
spoke V.
spring N.
spread V.
stay V.
station N.
stand V.
step N.
still ADV.
stick N.
stop V.
stopped V.
stood V.
store N.
story N.
stories N.
strong ADJ.
strange ADJ.
street N.
straight ADJ.
such ADJ.
suddenly ADV.
sugar N.
summer N.
sun N.
supper N.
sure ADJ.
sweet ADJ.
swim V.

table N.
tail N.
take V.
tall ADJ.
talk V.
teacher N.
tell V.
telephone N.
ten DET.
terrible ADJ.
that PRO.
than CONJ.
the DET.
them PRO.
these DET.
then ADV.
there ADV.
their DET.
this DET.
think V.
thought V.
three DET.
through PREP.
threw V.
thunder N.
time N.
tiny ADJ.
tired ADJ.
today N.
together ADV.
told V.
tomorrow N.
tongue N.
too ADV.
took V.
top N.
town N.
toward PREP.
to PREP.
trade V.
train N.
trap N.
tree N.
trip N.
tried V.
truck N.
trunk N.
try V.
turn V.
twelve DET.
two DET.

uncle N.
under PREP.
until CONJ.
up ADV.
use V.
us PRO.

very ADV.
village N.
visit V.
voice N.

wagon N.
wait V.
walk V.
wall N.
wanted V.
warm ADJ.
was V.
water N.
way N.
wear V.
well ADV.
went V.
were V.
west N.
wet ADJ.
we PRO.
what PRO.
when ADV.
where ADV.
wheel N.
which ADJ.
white ADJ.
while CONJ.
who PRO.
whole ADJ.
why ADV.
wide ADJ.
wife N.
will V.
wild ADJ.
winter N.
window N.
win V.
wind N.
wing N.
wish V.
wise ADJ.
with PREP.
woke V.
wolf N.
wonderful ADJ.
wonder V.
work V.
world N.
word N.
would V.
write V.
wrong ADJ.

yard N.
yellow ADJ.
yes INT.
yet ADV.
you PRO.
your DET.
young ADJ.

zoo N.

APPENDIX B

OUTLINE OF LANGUAGE ARTS FOR THE DEAF (1972 - 73 VERSION)

Lesson	Name	Description
1.	INTROD	Introduction to the course
2.	DIR1	Directions: first, second, last letter
3.	DIR2	Directions: after
4.	DIR3	Directions: first, second, third, fourth, last word
5.	DIR4	Directions: after, before, words
6.	DIR5	Directions: first, second, third, fourth, last, after the first, before the last, letters
7.	DIR6	Directions: more than one word (spaces between)
8.	DIR7	Directions: more than one word; first, second, third, fourth, last, before the last words
9.	DIR8	Directions: below, under
10.	DIR9	Directions: above, below, under
11.	RTA	Review test
12.	NAA	Common nouns, introduction
13.	NAB	Common nouns, continued
14.	DAA	Determiners introduced (a, an, the)
15.	MAA	Mixed drill: identification of nouns and determiners
16.	MAB	Mixed drill: nouns and determiners
17.	MAC	Mixed drill: nouns and determiners
18.	LAA	Vowels introduced
19.	DAB	Determiners: use of "a" and "an"
20.	MAD	Identification of nouns and determiners
21.	RTB	Review test
22.	NPAA	Introduction of noun phrase (determiner noun)
23.	NPAB	Noun phrase (single noun)
24.	DAC	Cardinals as determiners

25.	NAC	Plural nouns introduced
26.	NAD	Plural nouns (-s)
27.	NAE	Plural nouns (-s, -es)
28.	NAF	Plural nouns (-ies)
29.	NAG	Plural nouns, all types
30.	NAH	Plural nouns, irregular
31.	RTC	Review test
32.	DAD	Determiner-noun agreement in number (one,two)
33.	MAE	Identification of nouns and determiners (some, every, no)
34.	NPAC	Review noun phrases (including new determiners)
35.	DAE	Determiner-noun agreement (a, some)
36.	DAF	Review determiners (a, some)
37.	DAG	Determiner noun agreement (a, an, some)
38.	VAA	Verbs introduced (one-word verbs)
39.	VAB	One-word verbs, indentification
40.	MAF	Mixed review: verbs, determiners, nouns
41.	VAC	Review one and two word verbs
42.	MAG	Mixed drill: identify noun phrases and verbs
43.	RTD	Review test
44.	VAD	Modals introduced as part of two word verbs
45.	AJAA	Adjectives introduced (color, shape and size)
46.	AJAB	Adjectives (identify two in sentence)
47.	MAH	Mixed drill: nouns, adjectives, determiners, verbs
48.	MAI	Mixed drill: nouns, adjectives, determiners, verbs
50.	NPAD	Identify noun phrases with adjectives
51.	NPAE	Noun phrases with adjectives
52.	NPAF	First and second noun phrases
53.	AJAC	Predicate adjectives introduced

54.	MAJ	Mixed review: noun phrases and verbs
55.	RTE	Review test
56.	NPAG	Nominative noun phrases ("who", "what" questions)
57.	NPAH	Objective noun phrases ("what" questions)
58.	NPAI	Objective noun phrases ("what" questions without adverbials in question)
59.	NPAJ	Nominative and objective noun phrases ("who", "what" questions)
60.	NPAK	Nominative and objective noun phrases ("who", "what" questions)
61.	NPAL	Nominative and objective noun phrases ("who", "what" questions) (without adverbials in question)
62.	AJAD	Adjective transform introduced (subject noun phrase)
63.	AJAE	Adjective transform (position of adjective)
64.	AJAF	Adjective transform (object noun phrase)
65.	AJAG	Adjective transform (position of adjective)
66.	RTF	Review test
67.	SAA	Sentences: subject and predicate introduced
68.	SAB	Subject and predicate, continued
69.	PNAA	Pronouns introduced (I, you, we, he, she, it, they)
70.	PNAB	Pronouns introduced (me, him, her, it, us, them)
71.	NPAM	Pronouns as noun phrases
72.	SAC	Subject and predicate (pronoun subjects)
73.	PNAC	Pronoun-antecedent agreement (he, she, it)
74.	PNAD	Pronoun-antecedent agreement ("her father," "his sister")
75.	NPAN	Review singular and plural noun phrases
76.	PNAE	Pronoun-antecedent agreement (it, they)
77.	PNAF	Pronoun-antecedent agreement (he, she, it, they)
78.	RTG	Review test
79.	MAK	Mixed review: identify nouns and pronouns

80.	MAL	Mixed review: determiners, adjectives, nouns, verbs, pronouns
81.	PNAG	Pronoun-antecedent agreement (it, them)
82.	PNAH	Pronoun-antecedent agreement (her, him, it, them)
83.	SAD	Review subject and predicate
84.	PNAI	Pronoun-antecedent agreement (she, her, he, him)
85.	PNAJ	Pronoun-antecedent agreement (them, they)
86.	PNAK	Pronoun-antecedent agreement (them, they) (some compound subjects and objects)
87.	PNAL	Review of all pronoun-antecedent agreement
88.	RTH	Review test
89.	NPAO	Singular and plural noun phrases, including pronouns
90.	DAH	Determiner introduced (all)
91.	DAI	Determiner-noun agreement (all, every)
92.	DAJ	Double determiners (with "all" and cardinals)
93.	NPAP	Singular and plural noun phrases
94.	NAI	Review irregular plural nouns
95.	DAK	Review determiner number (a, an, some, cardinals)
96.	NAJ	Plural nouns with same form as singular
97.	NAK	Mixed review of plural nouns
98.	DAL	Singular and plural noun phrases (using "some" and "every")
99.	RTI	Review test
100.	SUAA	Identify subjects; some sentences beginning with adverbs
101.	SUAB	Singular and plural subjects
102.	SUAC	Singular and plural subjects
103.	SUAD	Compound subjects introduced
104.	SUAE	Singular and plural subjects, some compound
105.	SUAF	Number of subject; some sentences with adverbs

106.	VAE	Subject-verb agreement (choose the verb)
107.	VAF	Subject-verb agreement (choose the subject)
108.	VAG	Subject-verb agreement (some pronoun subjects) (choose the verb)
109.	RTJ	Review test
110.	VAH	Subject-verb agreement; some pronoun subjects including "I" and "you" (choose the verb)
111.	VAI	Subject-verb agreement; some pronoun subjects (choose the subject)
112.	VAJ	Subject-verb agreement; compound subjects (choose the verb)
113.	VAK	Subject-verb agreement; plural possessive pronouns with singular subjects (choose the verb)
114.	VAL	Subject-verb agreement; several kinds of subjects (choose the verb)
115.	VAM	Subject-verb agreement (choose subject or verb)
116.	SUAG	Number of subject; some irregular nouns
117.	SUAH	Number of subject; some nouns with same singular and plural
118.	RTK	Review test
119.	VAN	Subject-verb agreement; some nouns with same singular and plural (choose the verb)
120.	VAO	Subject-verb agreement (choose subject or verb)
121.	VAP	Y-ies inflections introduced
122.	VAQ	S-form of verbs ending in y: cry, stay, etc.
123.	VAR	-es inflection of verbs ending in -ch, -sh, -s, -x, -z
124.	VAS	Spelling of -es and s-forms
125.	VAT	Drill on s-forms; go-goes and do-does introduced
126.	VAU	S-form of HAVE introduced
127.	VAV	Mixed drill on s-forms; change from plural to singular subjects
128.	RTL	Review test
129.	PRAA	Introduce "prepositon" (in, to, of)

130.	PRAB	Identify prepositions (introduce for, with, on)
131.	PRAC	Introduce "prepositional phrase" (only PREP DET N)
132.	PRAD	Identify prepositional phrases (introduce at, by, from)
133.	PRAE	Identify prepositional phrases of several forms: PREP N, PREP DET N, PREP ADJ N, PREP DET ADJ N
134.	PRAF	Identify prepositional phrases of several forms (introduce after, into, over, before)
135.	PRAG	Identify first or second prepositional phrase
136.	BEAA	Introduce "is-are" forms (with compound subjects)
137.	BEAB	"is," "am," "are" with various subjects
138.	BEAC	Review "is," "am," "are" with constructed answers
139.	RTM	Review test
140.	VAW	Subject-verb (-s) agreement; some is-am-are (choose the verb)
141.	VAX	Subject-verb (-es) agreement; some is-am-are (choose the verb)
142.	VAY	Subject-verb agreement, some is-am-are (choose the noun or pronoun)
143.	VAZ	Spelling of s-forms; drill on "is" and "are"
144.	VBA	Review of s-forms: HAVE, GO, DO
145.	VBB	Review of s-forms: HAVE, GO, DO; constructed answers
146.	PRAH	Identify prepositional phrases of place
147.	PRAI	Prepositional phrases of place (fill in missing preposition)
148.	PRAJ	Prepositional phrases of place (choose correct preposition)
149.	RTN	Review test
150.	PRAK	Identify prepositional phrases of time
151.	PRAL	Prepositional phrases of time (fill in missing preposition)
152.	PRAM	Prepositional phrases of time (choose correct preposition)

153.	VBC	Introduce past tense
154.	VBD	Past tense construction (adding -d and -ed)
155.	VBE	Spelling of y-ied past tense
156.	VBF	Spelling of past tense with doubling of consonant
157.	VBG	Review of past tense; also HAVE, GO, DO
158.	VBH	Review of past tense; various verbs
159.	VBI	Change s-form to simple form of verb
160.	RTO	Review test
161.	VBJ	Present participles; "ing-form" introduced
162.	VBK	ing-forms with doubling of consonant
163.	VBL	ing-forms with dropping of final 'e'
164.	VBM	Review ing-forms; constructed answers
165.	VBN	Present progressive subject-verb agreement
166.	VBO	Present progressive subject-verb agreement; some constructed answers
167.	VBP	Present progressive agreement with pronouns; some constructed answers
168.	VBQ	"Present progressive" introduced; construct both parts
169.	VBR	Change from present to present progessive; construct both parts
170.	RTP	Review test
171.	SAE	Negative transform; "not-sentence" introduced, modals
8 9	SAF	Negative transform; insert "not" correctly
173.	NPAQ	"possessive noun phrase" introduced (subjects only)
174	NPAR	Identify possessive noun phrases (subjects and objects)
175.	NPAS	Possessive transform; identify correct sentence
176.	NPAT	Possessive noun phrase, singular nouns; contructed answers
177.	NPAU	Possessive noun phrase, plural nouns; constructed answers

178.	RTQ	Review test
179.	PRAN	Prepositional phrases of place and time (choose correct preposition)
180.	PRAO	Prepositional phrases of place and time (insert correct preposition)
181.	PRAP	Prepositional phrases of place and time (insert correct preposition)
182.	PRAQ	Prepositional phrases ("when" questions)
183.	PRAR	Prepositional phrases ("where" questions)
184.	PRAS	prepositional phrases ("when" and "where" questions
185.	VBS	Review past tense and present progessive; -ed, -ing
186.	VBT	Past tense and present progressive; -d, drop 'e' + ing
187.	VBU	Past tense and present progressive; y-ied, double consonant verbs
188.	VBV	Past tense and present progressive; various verbs
189.	RTR	Review test
190.	BEAD	Contractions of BE introduced; identify contraction
191.	BEAE	Contractions of BE; pronouns (constructed answers)
192.	BEAF	BE contractions; noun phrases (constructed answers)
193.	BEAG	Change BE contractions; pronouns (constructed answers)
194.	BEAH	Change BE contractions; noun phrases (constructed answers)
195.	NPAV	Possessive pronouns introduced
196.	NPAW	Possessive noun phrase, pronouns; constructed answers
197.	NPAX	Possessive noun phrase, pronouns; constructed answers
198.	NPAY	Possessive noun phrases, nouns and pronouns; constructed answers
199.	RTS	Review test
200.	SAG	Negative transform; forms of HAVE and BE
201.	SAH	Negative transform; insert "not" in sentence; HAVE and BE

202.	SAI	Review negative transform; HAVE, BE, and models
203.	MAM	Negative contractions introduced; HAVE, BE, and DO
204.	MAN	Negative contractions; BE (constructed answers)
205.	MAO	Negative contractions; HAVE, BE, DO (constructed answers)
206.	MAP	Change negative contractions; BE (constructed answers)
207.	MAQ	Change negative contractions; HAVE, BE, DO (constructed answers)
208.	RTT	Review test
209.	NPAZ	Noun phrases ("who," "what" questions)
210.	PRAT	Prepositional phrases ("when," "where" questions)
211.	MAR	Mixed review ("who," "what," "when," and "where" questions) (three questions for one statement)
212.	MAS	Mixed review ("who," "what," "when," and "where" questions) (three questions for one statement)
213.	SAJ	Identify model, have-word or be-word
214.	SAK	Introduce question transform; type model, have-word or be-word (CA gives transform)
215.	SAL	Question transform; "type the model or the have-word or the be-word" (CA gives transform)
216.	SAM	Question transform; identify correct sentence
217.	RTU	Review test

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